

**Criteria Grid**  
**Best Practices and Interventions for the Prevention and Awareness of Hepatitis C**

<b>Best Practice/Intervention:</b>	Tohme RA. et al. (2012) Transmission of hepatitis C virus infection through tattooing and piercing: a critical review. <i>Clinical Infectious Diseases</i> , 54(8):1167-1178.			
<b>Date of Review:</b>	June 15, 2015			
<b>Reviewer(s):</b>	Christine Hu			
<b>Part A</b>				
<b>Category:</b>	Basic Science <input type="checkbox"/> Clinical Science <input type="checkbox"/> Public Health/Epidemiology <input type="checkbox"/> Social Science <input type="checkbox"/> Programmatic Review <input checked="" type="checkbox"/>			
<b>Best Practice/Intervention:</b>	Focus:    Hepatitis C <input checked="" type="checkbox"/> Hepatitis C/HIV <input type="checkbox"/> Other: Hepatitis A _____ Level:        Group <input checked="" type="checkbox"/> Individual <input type="checkbox"/> Other: _____ Target Population: <u>Individuals with tattoos and piercings</u> Setting: Health care setting/Clinic <input checked="" type="checkbox"/> Home <input type="checkbox"/> Other: _____ Country of Origin: <u>USA</u> Language:    English <input checked="" type="checkbox"/> French <input type="checkbox"/> Other: _____			
<b>Part B</b>				
	<b>YES</b>	<b>NO</b>	<b>N/A</b>	<b>COMMENTS</b>
<i>Is the best practice/intervention a meta-analysis or primary research? <b>Please go to Comments section.</b></i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Meta-analysis; to evaluate the risk of hepatitis C infection from tattoos and piercings by conducting a review of available literature
<i>The best practice/intervention shows evidence of "scale up" ability</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
<i>The best practice/intervention shows evidence of transferability</i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The review is intended to inform recommendations to prevent and reduce risk of HCV transmission.
<i>The best practice/intervention shows evidence of adaptation</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	

<i>Do the methodology/results described allow the reviewer(s) to assess the generalizability of the results?</i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<b>YES</b>	<b>NO</b>	<b>N/A</b>	<b>COMMENTS</b>
<i>Are the best practices/methodology/results described applicable in developed countries?</i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Most studies included in the review originated from developed countries (ie. Canada, US, UK). Fewer studies originated from developing countries (Thailand, Brazil).
<i>Are the best practices/methodology/results described applicable in developing countries?</i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>The best practice/intervention has utilized a program evaluation process</i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Quality of evidence was evaluated using the Meta-analysis of Observational Studies in Epidemiology (MOOSE) and the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) guidelines.
<i>Consultation and feedback with community has taken place</i>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
<i>The best practice/intervention is sensitive to gender issues</i>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
<i>The best practice/intervention is sensitive to multicultural and marginalized populations</i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Wide variability in characteristics of study populations; review evaluated risk of HCV infection from tattooing in general population, blood donors, high-risk groups, prisoners, and veterans.
<i>The best practice/intervention is easily accessed/available electronically</i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Full article PDF can be found at <a href="http://cid.oxfordjournals.org/content/early/2012/01/19/cid.cir991.abstract">http://cid.oxfordjournals.org/content/early/2012/01/19/cid.cir991.abstract</a>
<i>Is there evidence of a cost effective analysis? If so, what does the evidence say? <b>Please go to Comments section</b></i>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
<i>How is the best practice/intervention funded? <b>Please go to Comments section</b></i>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	No funding stated.
<i>Is the best practice/intervention dependent on external funds?</i>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	

*Other relevant criteria:*

- Some studies showed significant increase in HCV infection risk when tattoo was done in non-professional settings
- High prevalence of tattooing among incarcerated persons
- Prisoners with history of IDU were 5 times more likely to have a tattoo and significantly more likely to acquire tattoo in prison

# Transmission of Hepatitis C Virus Infection Through Tattooing and Piercing: A Critical Review

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**Tattoos and piercings are increasing, especially among youths, but the risk of hepatitis C virus (HCV) infection from these practices has not been adequately assessed and there are conflicting findings in the literature. We evaluated the risk of HCV infection from tattooing and piercing using the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines. Studies that specified the venue of tattooing and/or piercing showed no definitive evidence for an increased risk of HCV infection when tattoos and piercings were received in professional parlors. However, the risk of HCV infection is significant, especially among high-risk groups (adjusted odds ratio, 2.0–3.6), when tattoos are applied in prison settings or by friends. Prevention interventions are needed to avoid the transmission of hepatitis C from tattooing and piercing in prisons, homes, and other potentially nonsterile settings. Youths also should be educated on the need to have tattoos and piercings performed under sterile conditions to avoid HCV infection.**

Hepatitis C Virus (HCV) infection, which is primarily transmitted through percutaneous exposure to contaminated blood, affects approximately 3 million Americans and is the leading cause of liver cancer in the United States [1]. In 2009, an estimated 16 000 new HCV infections occurred in the United States [2]. Although injection drug use (IDU) was the main mode of transmission among patients with available risk factor information, approximately 20% of patients denied exposure to traditional risk factors, such as IDU or other parenteral exposure [2]. From 1994 through 2006, recent tattooing and piercing were reported by 6% and 5% of respondents, respectively, with acute HCV infection in the Sentinel County Surveillance

System [3]. However, more than two-thirds of these patients also reported exposure to other risk factors, including IDU, which prevented drawing sound conclusions about the actual mode of transmission in those cases [3].

Although the practice of tattooing and piercing has been present for thousands of years, the numbers of tattoos and piercings have been increasing during the past decade, particularly among youths [4–7]. A 2004 survey among persons aged 18–50 years in the United States found that 24% of respondents had at least 1 tattoo and 14% had ever had body piercings [4]. Because of conflicting findings reported in the literature regarding the risk of transmission of hepatitis C through tattooing and piercing, the Centers for Disease Control and Prevention receives multiple inquiries by health professionals and laypersons for information on that matter.

Because of the increase in the practice of tattooing and piercing and the interest of health professionals and the public, we conducted a review of the literature to present the best available data on the risk of HCV transmission through these 2 modes. The review is

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intended to inform recommendations to prevent and reduce the risk of HCV transmission.

## METHODS

### Study Identification

Articles addressing the transmission of HCV through tattooing and piercing were identified through a literature search using PubMed and Medline. The search was limited to articles published from 1994 through July 2011 in all languages. A combination of the Medical Subject Headings terms “hepatitis C,” “HCV,” “tattooing,” “tattoo,” and “piercing” was used to identify potentially relevant abstracts and articles. Relevant references cited in identified studies were also assessed for inclusion. Articles published in languages other than English and French were evaluated on the basis of information included in the English abstract only. Unpublished, non-peer-reviewed studies were not retrieved because of the questionable reliability of such reports. The first author (R. T.) performed the search and retrieved the articles. Both authors (R. T. and S. H.) evaluated the validity of inclusion of each article and agreed on the strength of evidence in each based on preset ratings (Table 1).

The literature search resulted in the retrieval of 293 published articles or abstracts on HCV infection that included information about tattooing and/or piercing exposure. However, 231 studies were excluded because they were review papers ( $n = 47$ ), did not measure the risk of HCV infection through tattooing or piercing (ie, relied on descriptive statistics and did not include measures of association, such as odds ratios (ORs) and relative risk;  $n = 163$ ), did not control for any HCV infection risk factor (eg, drug use, transfusion before 1992, hemodialysis, contact with blood from HCV-infected person, and number of sex partners) when assessing the risk ( $n = 14$ ), were duplicate studies ( $n = 4$ ), were editorials or author responses ( $n = 2$ ), or relied on self-reported HCV infection ( $n = 1$ ). Therefore, a total of 62 articles were eligible for inclusion.

### Study Rating

We used the Meta-analysis of Observational Studies in Epidemiology and the Grades of Recommendation, Assessment, Development, and Evaluation guidelines to evaluate the quality of evidence [8, 9]. Table 1 summarizes the criteria used to evaluate and rate the strength of the evidence in each study. Final rating consisted of adding the rates in each category. Reports were evaluated on the basis of the study design, representativeness of the study population, adjustment for other HCV infection risk factors, and use of adequate laboratory testing methods for ascertainment of HCV infection. Cohort and case-control studies were given the highest rates, followed

**Table 1. Rating Criteria Used to Assess the Strength of the Evidence for Hepatitis C Virus Transmission Through Tattooing and Piercing**

Characteristic	Description of Study (Rating <sup>a</sup> )
Study design	Case series/report (1), cross-sectional (2), case-control (3), cohort (4)
Study population <sup>b</sup>	Hospital or clinic based (1), general population/surveillance (2)
Comparison population	Not representative (1), representative (2)
Outcome data	Prevalence (1), incidence (2)
Sample size	<100 cases for case-control or <2000 for cross-sectional studies (1), ≥100 cases for case-control or ≥2000 for cross-sectional studies (2)
Included and adjusted for confounders	Excluded IDU and transfusion (1), adjusted for IDU and transfusion (2)
Assessment of HCV infection	Serology only (1), serology and confirmatory RIBA or HCV RNA (2)
Specified venue of tattoo/piercing	No (1), yes (2)

Abbreviations: HCV, hepatitis C virus; IDU, injection drug use; RIBA, recombinant immunoblot assay.

<sup>a</sup> Higher number indicates increased strength of evidence.

<sup>b</sup> For studies not including blood donors or high-risk groups.

by cross-sectional studies. Case reports or case series were rated lowest, because the sample size from these types of studies is typically insufficient to quantify risk of HCV transmission. Studies that included incident cases of HCV infection; a sample size including at least 100 cases for case-control studies and 2000 individuals for cross-sectional studies (calculated considering a power of 80%, an  $\alpha$  of 0.05, and an estimated OR of 2 and taking into account the variability in HCV infection and tattoo prevalence rates in different study populations); controlled for other hepatitis C risk factors, including mainly IDU and transfusion of blood or blood products; and confirmed HCV infection with recombinant immunoblot assay or nucleic acid testing were given additional rating.

### Analysis

The magnitudes of the risk of HCV transmission through tattooing and piercing were presented as adjusted ORs (AORs) obtained by compiling AORs from studies that controlled for the most common routes of HCV transmission, particularly IDU. Because of the wide variability in the characteristics of study populations, we separately evaluated the risk of HCV infection from tattooing in the general population, blood donors, high-risk groups (ie, drug users, homeless persons, sex workers, and patients in sexually transmitted disease clinics), prisoners, and veterans. High-risk groups, prisoners, and veterans have been shown to have higher prevalence rates of IDU and HCV infection than the general population [1, 10–12], which

**Table 2. Studies Assessing the Transmission of Hepatitis C Virus Through Tattooing in the General Population, by Study Design and Year of Study**

Author(s)	Country (Years of Study)	Study Population	Sample Size	HCV Prevalence (%)	No. Tattooed (% HCV Infected)	Tattooing Reported as a Risk Factor; Adjusted OR (95% CI)	Location Where Tattoo Was Done
<b>Case-control studies</b>							
Mariano et al 2004 [13]	Italy (1997–2002)	Surveillance data	598 acute HCV cases; 7221 acute HAV controls	...	38 cases; 101 controls	Yes; OR = 5.6 (2.8–11)	...
Hand & Vasquez 2005 [14]	US (2000–02)	Hospital sample	320 cases; 307 controls <sup>a</sup>	...	182 cases; 67 controls	Yes; OR = 2.9 (1.9–4.6)	Friends, relatives, prisons
Delarocque-Astagneau et al 2007 <sup>b</sup> [15]	France (1998–2001)	Hepatology clinics; blood donors	64 cases; 227 controls	...	8 cases; 8 controls	No; OR = 2.8 (.7–10.7)	...
Karmochkine et al 2006 [16]	France (1997–2001)	Cases from clinics; controls from telephone survey	450 cases; 757 controls	...	...	No	...
Lasher et al 2005 [17]	Hawaii (1998–99)	Cases from surveillance; controls from telephone directory	222 cases; 699 controls	...	Professional: 67 cases vs 62 controls; nonprofessional: 32 cases vs 13 controls	Yes; OR = 2.0 (1.1–3.7)	Risk for HCV infection was double if tattoo was done in nonprofessional compared with professional settings
Silverman et al 2000 [18]	US (n/a)	Hospital sample	106 cases; 106 controls	9.4%	106 (6.6%)	No	...
Balasekaran et al 1999 [19]	US (1995–96)	Clinics	58 cases; 58 controls	...	25 cases; 9 controls	Yes; OR = 5.9 (1.1–30.7)	Mainly by family/friends
Dubois et al 1997 [20]	France (1994)	Population-based	72 cases; 144 controls	1.05%	...	No	...
Sun et al 1999 [21]	Taiwan (1991–92)	Community-based	272 cases; 282 controls	...	7 cases; 3 controls	No; OR = 3.1 (.7–13.3)	...
Mele et al 1995 [22]	Italy (1985–93)	Acute surveillance	363 cases; 4879 HAV controls	...	6 cases; 16 controls	No; OR = 2.5 (.8–7.8)	...
<b>Cross-sectional studies</b>							
Hwang et al 2006 [23]	US (2000–01)	College students	5282	0.9%	1327 (1%)	Professional: OR = 0.8 (.4–1.7); nonprofessional: OR = 3.5 (1.4–8.8)	Yes
Haley and Fisher 2001 [24]	US (1991–92)	Patients in spinal clinic	626	6.9%	113 (22.1%)	Yes; OR = 6.5 (2.9–14.8)	Commercial parlors
King et al 2009 [25]	France (2004)	National health insurance system	14 416	0.8%	1053 (5.3%)	Yes; OR = 2.4 (1.4–4.2)	...
Perez et al 2005 [26]	Puerto Rico (2001–02)	Community-based study	970	6.3%	120 (34.2%)	Yes; OR = 8.9 (1.7–44.7)	...
Nishioka et al 2002 [27]	Brazil (1998–2000)	Hospital-based	345	9.9%	182 (17.6%)	Yes; OR = 6.4 (1.3–31.8)	Mainly nonprofessional settings

Table 2 continued.

Author(s)	Country (Years of Study)	Study Population	Sample Size	HCV Prevalence (%)	No. Tattooed (% HCV Infected)	Tattooing Reported as a Risk Factor; Adjusted OR (95% CI)	Location Where Tattoo Was Done
La Torre et al 2006 [28]	Italy (1995–2000)	Household contacts of HCV patients	259	8.9%	8 (25%)	No; OR = 7.7 (1.0–60.2)	...
Dominguez et al 2001 [29]	Spain (1996)	Community-based	2142	2.5%	1258 (2.3%)	Yes; OR = 6.2 (1.9–20.9)	...
Brusaferro et al 1999 [30]	Italy (1994–95)	Household contacts of HCV-infected persons	514	10.3%	20 (80%)	Yes; OR = 2.5 (1.1–5.6)	...
Campello et al 2002 [31]	Italy (1994–95)	Community-based	2776	3.3%	...	Males: OR = 3.2 (.7–13.8); Females: OR = 2.6 (.2–29.3); Total: OR = 4.2 (1.5–15.2)	...

Abbreviations: CI, confidence interval; HAV, hepatitis A virus; HCV, hepatitis C virus; OR, odds ratio.

<sup>a</sup> Confirmatory HCV testing done for 40 cases only.

<sup>b</sup> Combined tattooing and piercing in 1 question.

could jeopardize analyses and conclusions if they are aggregated with low-risk groups. In addition, when information was available in the study, we separately assessed the risk of transmission of HCV infection from tattooing and piercing performed in professional parlors (ie, commercial venues that are licensed and regulated by health authorities), compared with those performed in nonprofessional settings under potentially nonsterile conditions (eg, by friends, at home, or in prison).

## RESULTS

### Association Between HCV Infection and Tattooing in the General Population

Table 2 summarizes findings from studies in the general population. Of 10 case-control studies, 6 reported no increased risk of HCV infection from tattooing when they controlled for IDU and other risk behaviors [15, 16, 18, 20–22], and 2 studies reported a 2–3 times higher risk for HCV infection when the tattoo was received in nonprofessional settings [14, 17]. One hospital-based case-control study including 64 patients and 128 control subjects did not find a significant association between tattooing and HCV infection in univariate analysis and, thus, excluded tattooing from the multivariate model [32]. Of the few reports showing an association between tattooing and HCV infection, 1 study compared 598 patients with acute HCV infection with 7221 control subjects with acute hepatitis A virus infection [13]. Patients with acute hepatitis A virus infection were younger and lived in other geographic areas, compared with those with acute HCV infection, which might affect the validity of the findings. Another study recruited 58 patients and 58 control subjects from a gastroenterology clinic, which limited generalizability of its findings [19]. More important, 29% of the originally enrolled study population admitted IDU when questioned, and control subjects were not tested to confirm that they were not HCV infected. Moreover, tattooing was frequently performed by family members or friends using unhygienic techniques [19].

A cross-sectional study including >5000 college students in the United States revealed no risk of HCV infection when the tattoo was performed in a professional setting (AOR, 0.8; 95% confidence interval [CI], 0.4–1.7), whereas the risk was significant for tattoos performed in nonprofessional settings (AOR, 3.5; 95% CI, 1.4–8.8) [23]. Other large cross-sectional studies indicated an association between tattooing and HCV infection but did not specify venue of tattooing [25, 26, 29]. A cross-sectional hospital-based survey in Brazil showed an increased risk of HCV infection among persons having a tattoo; however, more than half of individuals received their tattoos in nonprofessional settings using nonsterile instruments [27]. Moreover, 26% of those who had a tattoo reported IDU, compared with 0% of those who did not have a tattoo [33].

**Table 3. Studies Assessing the Transmission of Hepatitis C Virus Through Tattooing Among Blood Donors, by Study Design and Year of Study**

Author(s)	Country (Years of Study)	Sample Size	HCV Prevalence (%)	No. Tattooed (% HCV Infected)	Tattooing Reported as a Risk Factor; Adjusted OR (95% CI)
<b>Case-control studies</b>					
Goldman et al 2009 [35]	Canada (2005–06)	88 cases; 349 controls	...	20 cases; 38 controls	Tattoo >10 years ago: OR = 5.43 (1.82–16.2); tattoo past decade: OR = 2.35 (.77–7.22)
O'Brien et al 2008 [36]	Canada (1993–94; 2005–06)	1993: 107 cases; 428 controls  2005: 77 cases; 308 controls	...	1993: 32 cases; 21 controls  2005: 16 cases; 34 controls	Overall OR = 3.8 (2.0–7.3); 1993: OR = 8.3 (2.8–24.5); 2005: OR = 2.9 (1.2–7.0)
Kerzman et al 2007 [37]	Israel (2001–02)	50 cases; 128 controls	...	13 cases; 10 controls	No; OR = 1.1 (.1–9.2)
Thaikruea et al 2004 [38]	Thailand (2001–02)	166 cases; 329 controls	...	...	No
Tanwandee et al 2006 [39]	Thailand (n/a)	435 cases; 894 controls	...	...	No
Delage et al 1999 [40]	Canada (1993–94)	267 cases; 1068 controls	...	97 cases; 60 controls	Yes; OR = 5.7 (2.5–13.0)
Brandao & Fuchs 2002 [41]	Brazil (1995–96)	178 cases; 356 controls	1.10%	27 cases; 15 controls	Yes; OR = 4.4 (1.6–11.9)
Alavian et al 2002 [42]	Iran (1996–98)	193 cases; 196 controls	...	22 cases; 4 controls	No
Murphy et al 2000 [43]	US (1994–95)	758 cases; 1039 controls	...	205 cases; 52 controls	No
Conry-Cantilena et al 1996 [44]	US (1991–94)	248 cases; 131 controls	...	52 cases; 5 controls	No
Neal et al 1994 [45]	UK (1991–92)	35 cases; 150 controls	...	6 cases; 11 controls	Yes; OR = 3.3 (1.2–8.7)
Shev et al 1995 [46]	Sweden (1990–92)	51 cases; 51 controls	...	19 cases; 3 controls	Yes
<b>Cross-sectional studies</b>					
Khin et al 2010 [47]	Myanmar (2005–07)	65 240	0.95%	408 (0.98%)	No

All studies adjusted for injection drug use and other risks for HCV acquisition. Abbreviations: CI, confidence interval; HCV, hepatitis C virus; OR, odds ratio.

Only one early (1991–1992) cross-sectional study conducted among a selected US population (minority, indigent, and orthopedic patients) indicated a potential risk of HCV transmission by tattooing in commercial parlors [24]. One case report suggested potential hepatitis C transmission by tattooing in commercial parlors from reuse of nondisposable tattooing needles that are not appropriately sterilized [34].

#### Association Between HCV Infection and Tattooing Among Blood Donors

Persons with certain high-risk behaviors are excluded from blood donation, and several countries require persons who have recently had a tattoo or body piercing to defer from blood donation for at least 6 months, leading to lower rates of risk behaviors in this population. All studies conducted among blood donors did not inquire about the venue of tattooing. As shown in Table 3, almost all studies of these low-risk

individuals that controlled for major HCV infection risk factors have not reported an increased risk for HCV infection from tattooing [37–39, 42–44, 47]. Case-control studies conducted in large samples of blood donors in the United States did not show an increased risk of HCV transmission from tattooing, but did report significant associations between tattooing and IDU [43, 44].

Some studies suggest that tattoos received before 1995 increased the risk of HCV infection, whereas those received after 2005 did not [35, 36, 40, 41, 45, 46]. However, none of the studies recruited patients with incident cases, limiting the ability to draw temporal causality. One study involving blood donors in Canada found that the odds of HCV infection from tattooing were much lower among blood donors in 2005 (AOR, 2.9; 95% CI, 1.2–7.0) than among blood donors in 1993 (AOR, 8.3; 95% CI, 2.8–24.5) [32]. However, the venue of tattooing was not specified.

**Table 4. Studies Assessing the Transmission of Hepatitis C Virus Through Tattooing in Prisoners, High-Risk Groups, and Veterans, by Study Design and Year of Study**

Author(s)	Country (Year of Study)	Study Sample	Sample Size	HCV Prevalence (%)	No. Tattooed (% HCV Infected)	Tattooing Reported as a Risk Factor; Adjusted OR (95% CI)	Location Where Tattoo Was Done
Cohort studies							
Teutsch et al 2010 [48]	Australia (2005–09)	Prison	488	19% incidence rate: 31.6 per 100 person-years	354 (21.5%)	Yes; OR = 2.01 (1.01–4.01)	...
Butler et al 2004 [49]	Australia (1996–2001)	Prison	181	18% incidence rate: 7.1 per 100 person-years	52 (26.9%)	No	Mainly prison
Case-control studies							
Russell et al 2009 [50]	US (2001–04)	STD clinics	170 cases; 345 controls	3.4%	10% cases; 2.6% controls	No; OR = 1.87 (.62–5.65)	Nonprofessional settings
Cross-sectional studies							
Kheirandish et al 2009 [51]	Iran (2006)	Male IDUs in detention	454	80%	125 (89%)	Yes; OR = 2.33 (1.05–5.17)	...
Coelho et al 2009 [52]	Brazil (2003)	Prison	333	8.7%	120 (19.2%)	Yes; OR = 3.2 (1.05–10.0)	...
Lai et al 2007 [53]	Taiwan (2004–05)	Amphetamine abusers in prison	285	22.5%	178 (28.7%)	Yes; OR = 2.97 (1.37–6.43)	...
Liao et al 2006 [54]	Taiwan (2004–05)	Non-drug abuse Prisoners	297	10.1%	117 (14.5%)	Yes; OR = 2.24 (1.03–4.88)	...
Babudieri et al 2005 [55]	Italy (2001–02)	Prison inmates	973	38.0%	463 (51.2%)	Yes; OR = 1.91 (1.26–2.91)	...
Bair et al 2005 [56]	US (2000–01)	Detention center	1002	2.0%	506 (3.6%)	No; OR = 1.90 (.33–1.79)	...
Hellard et al 2007 [57]	Australia (2001)	Prisons	642	57.5%	449 (65.5%)	Yes; OR = 2.7 (1.4–5.2)	Prison
Murray et al 2003 [58]	US (1999–2001)	Incarcerated youths	305	2.0%	101 (2%)	No	Nonprofessional settings
Miller et al 2009 [59]	Australia (2005–07)	IDU	355	68.9%	201 (68%)	No	Multiple locations
Mehta et al 2010 <sup>a</sup> [60]	India (2005–06)	IDU	1158	55%	...	Yes; PR = 1.26 (1.14–1.41)	...
Samuel et al 2001 <sup>a</sup> [61]	US (1995–97)	IDU	945	82.2%	577 (84.8%)	Not in prison/jail: OR = 1.7 (0.9–2.9); in prison/jail: OR = 3.4 (1.6–7.5)	Prisons, friends, relatives
Nurutdinova et al 2011 <sup>a</sup> [62]	US (1998–2004)	African American women who abuse substances	782	21.2%	210 (26.7%)	Yes; OR = 2.05 (1.15–3.66)	...
Gyarmathy et al 2002 <sup>a</sup> [63]	US (1996–2001)	Noninjection heroin users	483	26%	99 (18.2%)	Never injectors: OR = 2.2 (1.0–4.7); former injectors: OR = 3.5 (1.3–9.6)	...
Howe et al 2005 [64]	US (2000)	Noninjection drug users	722	3.9%	265 (4.5%)	Yes; OR = 3.6 (1.2–11.3)	Friends, relatives
Roy et al 2001 [65]	Montreal, Canada (1995–96)	Street youths	437	12.6%	247 (18.2%)	No; OR = 1.8 (.9–3.6)	...

Table 4 continued.

Author(s)	Country (Year of Study)	Study Sample	Sample Size	HCV Prevalence (%)	No. Tattooed (% HCV Infected)	Tattooing Reported as a Risk Factor; Adjusted OR (95% CI)	Location Where Tattoo Was Done
Zuniga et al 2006 <sup>b</sup> [66]	US (2001–03)	Veterans	2263	4.6%	681 (7.0%)	Yes; OR = 2.12 (1.28–3.49)	...
Dominitz et al 2005 [11]	US (1998–2000)	Veterans	1288	4.0%	247 (11.3%)	Yes; OR = 2.9 (1.4–5.8)	...
Briggs et al 2001 [12]	US (1998–99)	Veterans	1032	17.7%	256 (34.7%)	Yes; OR = 2.93 (1.70–5.08)	...

Abbreviations: CI, confidence interval; HCV, hepatitis C virus; IDU, injection drug user; OR, odds ratio; PR, prevalence ratio; STD, sexually transmitted disease.

<sup>a</sup> Confirmatory HCV testing was not done.

<sup>b</sup> Combined both tattoo and body piercing.

### Association Between HCV Infection and Tattooing Among High-Risk Groups

Table 4 summarizes the findings of studies that assessed the risk of HCV infection from tattooing in high-risk groups. Two cohort studies conducted among prisoners in Australia reported discrepant findings. The study that recruited a larger sample (n = 488) showed a significant association between tattooing and HCV infection [48]; the other study, which did not find such an association, recruited 181 prisoners, a smaller number, which might have limited the power to demonstrate statistical significance [49]. Although cohort studies followed up with prisoners over >4 years, the presence of tattooing was assessed during their lifetime and not necessarily during their time in prison; this hinders temporal linkage between tattooing and HCV infection [48, 49].

Results from cross-sectional studies involving incarcerated individuals have been inconsistent. Two studies conducted in the United States among incarcerated youths reported no increased risk of HCV infection among those who were tattooed, even if the tattoo was applied in a nonprofessional setting [56, 58]. However, several studies from other countries found a 2–3 times higher likelihood of HCV infection among prisoners who had a tattoo [51–55, 57]. Of note, approximately 90% of prisoners received tattoos in nonprofessional settings [57]. Case reports of acute HCV infection from tattooing in prison suggest that tattooing could be the source of infection [67–69]. One case report documented seroconversion in a prisoner after a negative hepatitis C test result, and tattooing in prison was the only risk factor during the incubation period [67].

Findings from cross-sectional studies involving injection drug users varied by country, duration of injection, and incarceration [59–61]. Although the risk of HCV infection increased by 3 times among injection drug users who had tattoos applied in prison or jail, the risk was not statistically significant if the tattoos were received outside prison or jail [61]. Current noninjecting heroin users who reported never injecting drugs did not have a significantly increased risk of HCV infection from tattooing, whereas former injectors who had a tattoo had 3 times higher risk of HCV infection [63]. Other studies involving noninjection drug users reported a 2–3 times higher risk of HCV infection among those who had a tattoo [62, 64], and 1 study specified that the tattoos were applied by friends or relatives [64].

Studies involving street youths and homeless persons did not find an association between HCV infection and tattoos [65, 70], with 57% of homeless persons reporting IDU and 41% of them having shared needles with others [70].

Tattoos are highly prevalent among soldiers. Almost 36% of soldiers in the US Army had at least 1 tattoo, and 76% experienced bleeding after the procedure, which might promote transmission of blood-borne infections [71]. Studies that

**Table 5. Studies Assessing the Transmission of Hepatitis C Virus Through Piercing Among Different Study Populations**

Author(s)	Country (Year of Study)	Study Sample	Sample Size	HCV Prevalence (%)	No. Pierced (% HCV Infected)	Piercing Reported as a Risk Factor; Adjusted OR (95% CI)	Location Where Piercing Was Done
Cohort study							
Bruneau et al 2010 [72]	Canada (2004–08)	IDU	145	28%	17 (35%)	No; HR = 0.96 (.3–2.7)	...
Case Control studies							
Mariano et al 2004 [13]	Italy (1997–2002)	Surveillance data	598 acute HCV cases; 7221 acute HAV controls	...	42 cases; 224 controls	Yes; OR = 2.4 (1.2–4.8)	...
Karmochkine et al 2006 [16]	France (1997–2001)	Cases from clinics; controls from telephone survey	450 cases; 757 controls	...	...	No	...
Lasher et al 2005 [17]	US (1998–99)	Cases from surveillance; controls from telephone directory	222 cases; 699 controls	...	13 cases; 14 controls	No; OR = 1.5 (.4–1.6)	...
Balasekaran et al 1999 <sup>a</sup> [19]	US (1995–96)	Clinics	58 cases; 58 controls	...	Men: 7 cases; 5 controls. Women: 34 cases; 36 controls	No; Men: OR = 1.7 (.4–7.0); Women: OR = 0.3 (.03–3.2)	...
Mele et al 1995 <sup>a</sup> [22]	Italy (1985–93)	Acute surveillance	363 cases; 4879 HAV controls	...	12 cases; 74 controls	Yes; OR = 2.8 (1.3–5.8)	...
He et al 2011 <sup>a</sup> [73]	China (2006–07)	Blood donors	305 cases; 610 controls	0.53%	98 cases; 62 controls	Yes; OR = 7.3 (3.3–16.3)	...
Goldman et al 2009 [35]	Canada (2005–06)	Blood donors	88 cases; 349 controls	...	...	No	...
Kerzman et al 2007 [37]	Israel (2001–02)	Blood donors	50 cases; 128 controls	...	11 cases; 37 controls	No; OR = 0.8 (.4–1.8)	...
Thaikruea et al 2004 [38]	Thailand (2001–02)	Blood donors	166 cases; 329 controls	...	49 cases; 35 controls	No	...
Tanwandee et al 2006 [39]	Thailand (n/a)	Blood donors	435 cases; 894 controls	...	...	No	...
Murphy et al 2000 [43]	US (1994–95)	Blood donors	758 cases; 1039 controls	...	425 cases; 416 controls	Yes; OR = 2.0 (1.1–3.7)	...
Conry-Cantilena et al 1996 <sup>a</sup> [44]	US (1991–94)	Blood donors	248 cases; 131 controls	...	42 cases; 0 controls	Yes (men): OR = ∞; No (women)	...
Neal et al 1994 [45]	UK (1991–92)	Blood donors	35 cases; 150 controls	...	23 cases; 71 controls (ear)	No; OR = 1.4 (.7–2.9)	...
Cross-sectional studies							
Hwang et al 2006 [23]	US (2000–01)	College students	5282	0.9%	1108 (0.7%)	No; OR = 0.76 (.36–1.62)	...
King et al 2009 [25]	France (2004)	National seroprevalence survey	14 416	0.8%	5398 (1.8%)	No	...

Table 5 continued.

Author(s)	Country (Year of Study)	Study Sample	Sample Size	HCV Prevalence (%)	No. Pierced (% HCV Infected)	Piercing Reported as a Risk Factor; Adjusted OR (95% CI)	Location Where Piercing Was Done
Perez et al 2005 [26]	Puerto Rico (2001–02)	Community-based study	970	6.3%	247 (4.4%)	No	...
Khin et al 2010 [47]	Myanmar (2005–07)	Blood donors	65 240	0.95%	638 (0.31%)	No	...
Bair et al 2005 [56]	US (2000–01)	Detention center	1002	2.0%	506 (3.6%)	No	...
Murray et al 2003 [58]	US (1999–2001)	Newly incarcerated youths	305	2.0%	163 (3.10%)	No	Nonprofessional settings
Miller et al 2009 [59]	Australia (2005–07)	IDU	355	68.9%	117 (58.1%)	No	Multiple locations assessed
Roy et al 2001 [65]	Canada (1995–96)	Street youths	437	12.6%	342 (13.4%)	No	...
Dominitz et al 2005 [11]	US (1998–2000)	Veterans	1288	4.0%	178 (12.9%)	No; OR = 2.2 (.7–6.8) <sup>b</sup>	...

Abbreviations: CI, confidence interval; HAV, hepatitis A virus; HCV, hepatitis C virus; IDU, injection drug user; OR, odds ratio.

<sup>a</sup> Ear piercing.

<sup>b</sup> OR adjusted for IDU only.

recruited >1000 veterans found almost 3 times higher risk of HCV infection among veterans with a tattoo, compared with those who did not have a tattoo (Table 4) [11, 12, 66]. However, in all studies, the researchers did not inquire about the venue of tattooing.

### Association Between HCV Infection and Piercing

Table 5 summarizes findings of studies that assessed the risk of HCV infection among those who reported having a body or ear piercing. The majority of studies did not distinguish between piercings received in professional settings from those received in nonprofessional settings. Only 5 of 23 studies reported an increased risk of HCV infection among persons with a piercing (AOR, 2.0–7.3) [13, 22, 43, 44, 73]. Of the 5, 2 were conducted among blood donors in the United States during the early 1990s [43, 44], with 1 study showing a significant association between ear piercing and HCV infection only among men and no association among women [44].

Moreover, a number of cohort, case-control, and cross-sectional studies involving high-risk groups did not find significant associations between body piercing and HCV infection in univariate analysis and, thus, did not include this variable in the multivariable model [32, 48, 62, 64]. A cross-sectional study including >5000 college students in the United States did not reveal an increased risk of HCV infection among those with a body piercing [23]. Acute HCV infection occurred after ear piercing with a gun at a jeweler in an older French woman with no other identified risk factor [74]. Swapping body piercing jewelry was also reported as a potential source of HCV infection in another case report [75].

## DISCUSSION

This article critically reviewed the literature for the risk of transmission of HCV infection through tattooing and piercing by distinguishing among different study populations and careful examination of potential study limitations. To date, there is no definitive evidence that such infections occur when sterile equipment is used. Of note, no outbreaks of HCV infection have been detected in the United States that originate from professional tattoo or piercing parlors. In addition, recent cohort and case-control studies including samples from the general population or blood donors in developed countries did not show an increased risk of HCV infection with body or ear piercing.

Although commercial parlors have not been implicated in HCV transmission, such transmission could occur at different stages of tattooing and piercing, from the reuse of nondisposable needles, inappropriate sterilization of equipment, or reuse of ink contaminated with blood from an infected person. Although data on survival of hepatitis C in tattooing or piercing

equipment are not available, survival of HCV ranges from a few days on inanimate surfaces to almost 1 month in propofol solutions [76–79]. Because of the potential risk of transmission of blood-borne pathogens through tattooing and piercing, the US Occupational Safety and Health Administration includes these practices in their blood-borne safety standards [80]. In addition, several countries and more than two-thirds of state health jurisdictions in the United States have additional regulations for tattoo and piercing parlors [81].

Although the majority of reviewed studies failed to report the venue of tattoo and/or piercing, studies that specified the location in the general population showed a significant increase in risk of HCV infection when the tattoo was done in non-professional settings [14, 17, 19, 23, 27]. In addition, the risk of HCV infection is significant among high-risk groups when nonsterile tattooing equipment is used, especially in unregulated settings, such as homes or prison (AOR, 2.0–3.6) [48, 57, 61, 64]. Although location of tattooing was not specified in all studies including prisoners, this population seems to be at increased risk of HCV infection from tattooing, according to the available data [48, 51–56]. Tattooing in prison is of particular concern because of the high prevalence of tattooing among incarcerated persons, reaching up to 40% in some studies [57, 82]. Tattooing in this setting typically is performed using nonsterile equipment, such as guitar strings, paper clips, or sewing needles, which are usually cleaned by heating or use of boiling water [82]. The strong association between tattoos received in prison and HCV infection may in part be confounded by other high-risk behaviors, such as IDU, or may be a consequence of an association between history of imprisonment and dangerous lifestyles. Prisoners with a history of IDU were 5 times more likely to have a tattoo and were significantly more likely to have acquired the tattoo in prison [57]. Qualitative studies might be helpful to identify successful techniques to prevent blood-borne viruses in prison environments and among high-risk groups [61].

A major limitation, common to all studies, was the reliance on self-reports for the ascertainment of IDU. Tattoos and drugs often coexist, and the risk of HCV infection among tattooed individuals consistently has been shown to be related to drug use [57, 59, 63, 65]. Of note, in one study, 67% of the participants who initially denied drug use at study entry subsequently admitted IDU or intranasal cocaine use [18]. In addition, almost all cohort and case-control studies did not recruit patients with incident cases of HCV infection and asked about ever having a tattoo or piercing, which hinders drawing temporal causal relationships between HCV infection and tattooing or piercing. Finally, most studies did not inquire about the venue of receipt of the tattoo or piercing. Therefore, future studies that inquire about tattooing and piercing need to specify the venue where they were received

to draw more scientifically sound conclusions about the association between HCV infection and those exposures.

Although our original objective was to conduct a meta-analysis, several of the studies that found no association between HCV infection and tattooing or piercing in the univariate analysis either did not include those exposures in the multivariable analysis or did not report the AOR. Therefore, pooling the results of studies with available ORs would be inappropriate and would lead to inaccurate and false conclusions. It is recommended that upcoming studies report AORs even if they are not significant to facilitate the conduct of meta-analyses in the future.

Despite these limitations, we could evaluate the quality of the evidence in each study. The findings emphasize the need to prevent hepatitis C transmission from use of unsterile tattooing and piercing equipment, especially in prisons. Because of the increasing prevalence of tattooing and piercings, particularly among youths, awareness campaigns should highlight the danger of such procedures in unregulated and potentially unsterile environments, such as homes and prisons. In addition, tattoo and piercing parlors need to be educated about and monitored for use of proper infection control procedures to avoid isolated cases of HCV infection and other infections.

## Note

**Potential conflicts of interest.** All authors: No reported conflicts.

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## References

1. Armstrong GL, Wasley A, Simard EP, et al. The prevalence of hepatitis C virus infection in the United States, 1999 through 2002. *Ann Intern Med* **2006**; 144:705–14.
2. Centers for Disease Control and Prevention. Viral hepatitis surveillance—United States. 2009. Available at: <http://www.cdc.gov/hepatitis/Statistics/2009Surveillance/PDFs/2009HepSurveillanceRpt.pdf>. Accessed 6 September 2011.
3. Williams IT, Bell BP, Kuhnert W, Alter MJ. Incidence and transmission patterns of acute hepatitis C in the United States, 1982–2006. *Arch Intern Med* **2011**; 171:242–8.
4. Laumann AE, Derick AJ. Tattoos and body piercings in the United States: a national data set. *J Am Acad Dermatol* **2006**; 55:413–21.
5. Mayers LB, Chiffreller SH. Body art (body piercing and tattooing) among undergraduate university students: “then and now.” *J Adolesc Health* **2008**; 42:201–3.
6. Carroll ST, Riffenburgh RH, Roberts TA, Myhre EB. Tattoos and body piercings as indicators of adolescent risk-taking behaviors. *Pediatrics* **2002**; 109:1021–7.
7. Stieger S, Pietschnig J, Kastner CK, Voracek M, Swami V. Prevalence and acceptance of tattoos and piercings: a survey of young adults from the southern German-speaking area of central Europe. *Percept Mot Skills* **2010**; 110:1065–74.
8. Stroup D, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. *JAMA* **2000**; 283: 2008–12.

9. Atkins D, Best D, Briss PA, et al. (GRADE) Working Group. Grading quality of evidence and strength of recommendations. *BMJ* **2004**; 328:1490–4.
10. Vescio MF, Longo B, Babudieri S, et al. Correlates of hepatitis C virus seropositivity in prison inmates: a meta-analysis. *J Epidemiol Community Health* **2008**; 62:305–13.
11. Dominitz JA, Boyko EJ, Koepsell TD, Heagerty PJ, Maynard C, Sporleder JL. VA Cooperative Study Group 488. Elevated prevalence of hepatitis C infection in users of United States veterans medical centers. *Hepatology* **2005**; 41:88–96.
12. Briggs ME, Baker C, Hall R, et al. Prevalence and risk factors for hepatitis C virus infection at an urban veterans administration medical center. *Hepatology* **2001**; 34:1200–5.
13. Mariano A, Mele A, Tosti ME, et al. Role of beauty treatment in the spread of parenterally transmitted hepatitis viruses in Italy. *J Med Virol* **2004**; 74:216–20.
14. Hand WL, Vasquez Y. Risk factors for hepatitis C on the Texas-Mexico border. *Am J Gastroenterol* **2005**; 100:2180–5.
15. Delarocque-Astagneau E, Pillonel J, De Valk H, Perra A, Laperche S, Desenclos JC. An incident case-control study of modes of hepatitis C virus transmission in France. *Ann Epidemiol* **2007**; 17:755–62.
16. Karmochkine M, Carrat F, Dos Santos O, Cacoub P, Raguin G. for the GERMIVIC Study Group. A case-control study of risk factors for hepatitis C infection in patients with unexplained routes of infection. *J Viral Hepat* **2006**; 13:775–82.
17. Lasher LE, Elm JL, Hoang Q, et al. A case control investigation of hepatitis C risk factors in Hawaii. *Hawaii Med J* **2005**; 64:296–304.
18. Silverman AL, Sekhon JS, Saginaw SJ, Wiedbrauk D, Balasubramaniam M, Gordon SC. Tattoo application is not associated with an increased risk for chronic viral hepatitis. *Am J Gastroenterol* **2000**; 95:1312–5.
19. Balasekaran R, Bulterys M, Jamal MM, et al. A case-control study of risk factors for sporadic hepatitis C virus infection in the southwestern United States. *Am J Gastroenterol* **1999**; 94:1341–6.
20. Dubois F, Desenclos JC, Mariotte N, Goudeau A. The Collaborative Study Group. Hepatitis C in a French population-based survey, 1994: seroprevalence, frequency of viremia, genotype distribution, and risk factors. *Hepatology* **1997**; 25:1490–6.
21. Sun CA, Chen HC, Lu CF, et al. Transmission of hepatitis C virus in Taiwan: prevalence and risk factors based on a nationwide survey. *J Med Virol* **1999**; 59:290–6.
22. Mele A, Corona R, Tosti ME, et al. Beauty treatments and risk of parenterally transmitted hepatitis: results from the hepatitis surveillance system in Italy. *Scand J Infect Dis* **1995**; 27:441–4.
23. Hwang LY, Kramer JR, Troisi C, et al. Relationship of cosmetic procedures and drug use to hepatitis C and hepatitis B virus infections in a low-risk population. *Hepatology* **2006**; 44:341–51.
24. Haley RW, Fisher RP. Commercial tattooing as a potentially important source of hepatitis C infection: clinical epidemiology of 626 consecutive patients unaware of their hepatitis C serologic status. *Medicine* **2001**; 80:134–51.
25. King LA, Le Strat Y, Meffre C, Delarocque-Astagneau E, Desenclos JC. Assessment and proposal of a new combination of screening criteria for hepatitis C in France. *Eur J Public Health* **2009**; 19:527–33.
26. Perez CM, Suarez E, Torres EA, Roman K, Colon V. Seroprevalence of hepatitis C virus and associated risk behaviors: a population-based study in San Juan, Puerto Rico. *Int J Epidemiol* **2005**; 34:593–9.
27. Nishioka S de A, Gyorkos TW, Joseph L, Collet JP, Maclean JD. Tattooing and risk for transfusion-transmitted diseases: the role of the type, number and design of the tattoos, and the conditions in which they were performed. *Epidemiol Infect* **2002**; 128:63–71.
28. La Torre G, Miele L, Mannocci A, et al. Correlates of HCV seropositivity among familial contacts of HCV infected patients. *BMC Public Health* **2006**; 6:237.
29. Dominguez A, Bruguera M, Vidal J, Plans P, Salleras L. Community-based seroepidemiological survey of HCV infection in Catalonia, Spain. *J Med Virol* **2001**; 65:688–93.
30. Brusaferrero S, Barbone F, Andrian P, et al. A study on the role of the family and other risk factors in HCV transmission. *Eur J Epidemiol* **1999**; 15:125–32.
31. Campello C, Poli A, Dal Molin G, Bezossi-Valentini F. Seroprevalence, viremia and genotype distribution of hepatitis C virus: a community-based population study in northern Italy. *Infection* **2002**; 30:7–12.
32. Kim YS, Ahn YO, Kim DW. A case-control study on the risk factors of hepatitis C virus infection among Koreans. *J Korean Med Sci* **1996**; 11:38–43.
33. Nishioka S de A, Gyorkos TW, Joseph L, Collet JP, Maclean JD. Tattooing and transfusion-transmitted diseases in Brazil: a hospital-based cross-sectional matched study. *Eur J Epidemiol* **2003**; 18: 441–9.
34. Sun DX, Zhang FG, Geng YQ, Xi DS. Hepatitis C transmission by cosmetic tattooing in women. *Lancet* **1996**; 347:541.
35. Goldman M, Xi G, Yi QL, Fan W, O'Brien SF. Reassessment of deferrals for tattooing and piercing. *Transfusion* **2009**; 49:648–54.
36. O'Brien SF, Fan W, Xi G, et al. Declining hepatitis C rates in first time blood donors: insight from surveillance and case-control risk factor studies. *Transfusion* **2008**; 48:902–9.
37. Kerzman H, Green MS, Shinar E. Risk factors for hepatitis C virus infection among blood donors in Israel: a case-control study between native Israelis and immigrants from the former Soviet Union. *Transfusion* **2007**; 47:1189–96.
38. Thaikrua L, Thongsawat S, Maneekarn N, Netski D, Thomas DL, Nelson KE. Risk factors for hepatitis C virus infection among blood donors in northern Thailand. *Transfusion* **2004**; 44:1433–40.
39. Tanwandee T, Piratvisuth T, Phornphutkul K, Mairiang P, Permpikul P, Poovorawan Y. Risk factors of hepatitis C virus infection in blood donors in Thailand: a multicenter case-control study. *J Med Assoc Thai* **2006**; 89(Suppl 5):S79–83.
40. Delage G, Infante-Rivard C, Chiavetta JA, Willems B, Pi D, Fast M. Risk factors for acquisition of hepatitis C virus infection in blood donors: results of a case-control study. *Gastroenterology* **1999**; 116: 893–9.
41. Brandao AB, Fuchs SC. Risk factors for hepatitis C virus infection among blood donors in southern Brazil: a case-control study. *BMC Gastroenterol* **2002**; 2:18.
42. Alavian SM, Gholami B, Masarrat S. Hepatitis C risk factors in Iranian volunteer blood donors: a case-control study. *J Gastroenterol Hepatol* **2002**; 17:1092–7.
43. Murphy EL, Bryzman SM, Glynn SA, et al. Risk factors for hepatitis C virus infection in United States blood donors. *Hepatology* **2000**; 31: 756–62.
44. Conry-Cantilena C, VanRaden M, Gibble J, et al. Routes of infection, viremia, and liver disease in blood donors found to have hepatitis C virus infection. *N Engl J Med* **1996**; 334:1691–6.
45. Neal KR, Jones DA, Killely D, James V. Risk factors for hepatitis C virus infection. A case-control study of blood donors in the Trent region (UK). *Epidemiol Infect* **1994**; 112:595–601.
46. Shev S, Hermodsson S, Lindholm A, Malm E, Widell A, Norkrans G. Risk factor exposure among hepatitis C virus RNA positive Swedish blood donors—the role of parenteral and sexual transmission. *Scand J Infect Dis* **1995**; 27:99–104.
47. Khin M, Oo SS, Oo KM, Shimono K, Koide N, Okada S. Prevalence and factors associated with hepatitis C virus infection among Myanmar blood donors. *Acta Med Okayama* **2010**; 64:317–21.
48. Teutsch S, Luciani F, Scheuer N, et al. Incidence of primary hepatitis C infection and risk factors for transmission in an Australian prisoner cohort. *BMC Public Health* **2010**; 10:633.
49. Butler T, Kariminia A, Levy M, Kaldor J. Prisoners are at risk for hepatitis C transmission. *Eur J Epidemiol* **2004**; 19:1119–22.
50. Russell M, Chen MJ, Nochajski TH, Testa M, Zimmerman SJ, Hughes PS. Risky sexual behavior, bleeding caused by intimate partner violence, and hepatitis C virus infection in patients of a sexually transmitted disease clinic. *Am J Public Health* **2009**; 99:173–9.

51. Kheirandish P, SeyedAlinaghi SA, Jahani MR, et al. Prevalence and correlates of hepatitis C infection among male injection drug users in detention, Tehran, Iran. *J Urban Health* **2009**; 86:902–8.
52. Coelho HC, de Olivera SA, Miguel JC, et al. Predictive markers for hepatitis C virus infection among Brazilian inmates. *Rev Soc Bras Med Trop* **2009**; 42:369–72.
53. Lai SW, Chang WL, Peng CY, Liao KF. Viral hepatitis among male amphetamine-inhaling abusers. *Intern Med J* **2007**; 37:472–7.
54. Liao KF, Lai SW, Chang WL, Hsu NY. Screening for viral hepatitis among male non-drug-abuse prisoners. *Scand J Gastroenterol* **2006**; 41:969–73.
55. Babudieri S, Longo B, Sarmati L, et al. Correlates of HIV, HBV, and HCV infections in a prison inmate population: results from a multi-centre study in Italy. *J Med Virol* **2005**; 76:311–7.
56. Bair RM, Baillargeon JG, Kelly PJ, et al. Prevalence and risk factors for hepatitis C virus infection among adolescents in detention. *Arch Pediatr Adolesc Med* **2005**; 159:1015–8.
57. Hellard ME, Aitken CK, Hocking JS. Tattooing in prisons—not such a pretty picture. *Am J Infect Control* **2007**; 35:477–80.
58. Murray KF, Richardson LP, Morishima C, Owens JWM, Gretch DR. Prevalence of hepatitis C virus infection and risk factors in an incarcerated juvenile population: a pilot study. *Pediatrics* **2003**; 111:153–7.
59. Miller ER, Hellard ME, Bowden S, Bharadwaj M, Aitken CK. Markers and risk factors for HCV, HBV and HIV in a network of injecting drug users in Melbourne, Australia. *J Infect* **2009**; 58:375–82.
60. Mehta SH, Vogt SL, Srikrishnan AK, et al. Epidemiology of hepatitis C virus infection and liver disease among injection drug users (IDUs) in Chennai, India. *Ind J Med Res* **2010**; 132:706–14.
61. Samuel MC, Doherty PM, Bulterys M, Jenison SA. Association between heroin use, needle sharing and tattoos received in prison with hepatitis B and C positivity among street-recruited injecting drug users in New Mexico, USA. *Epidemiol Infect* **2001**; 127:475–84.
62. Nurutdinova D, Abdallah AB, Bradford S, O’Leary CC, Cottler LB. Risk factors associated with hepatitis C among female substance users enrolled in community-based HIV prevention studies. *BMC Res Notes* **2011**; 4:126.
63. Gyarmathy VA, Neaigus A, Miller M, Friedman SR, Des Jarlais DC. Risk correlates of prevalent HIV, hepatitis B virus, and hepatitis C virus infections among noninjecting heroin users. *J Acquir Immune Defic Syndr* **2002**; 30:448–56.
64. Howe CJ, Fuller CM, Ompad DC, et al. Association of sex, hygiene and drug equipment sharing with hepatitis C virus infection among non-injecting drug users in New York City. *Drug Alcohol Depend* **2005**; 79:389–95.
65. Roy E, Haley N, Leclerc P, Boivin JF, Cedras L, Vincelette J. Risk factors for hepatitis C virus infection among street youths. *CMAJ* **2001**; 165:557–60.
66. Zuniga IA, Chen JJ, Lane DS, Allmer J, Jimenez-Lucho VE. Analysis of hepatitis C screening program for US veterans. *Epidemiol Infect* **2006**; 134:249–57.
67. Tsang TH, Horowitz E, Vugia DC. Transmission of hepatitis C through tattooing in a United States prison. *Am J Gastroenterol* **2001**; 96:1304–5.
68. Post JJ, Dolan KA, Whybin LR, Carter IW, Haber PS, Lloyd AR. Acute hepatitis C virus infection in an Australian prison inmate: tattooing as a possible transmission route. *Med J Aust* **2001**; 174:183–4.
69. Thompson SC, Hernberger F, Wale E, Crofts N. Hepatitis C transmission through tattooing: a case report. *Aust N Z J Public Health* **1996**; 20:317–8.
70. Sherriff LC, Mayon-White RT. A survey of hepatitis C prevalence amongst the homeless community of Oxford. *J Public Health Med* **2003**; 25:358–61.
71. Armstrong ML, Murphy KP, Sallee A, Watson MG. Tattooed army soldiers: examining the incidence, behavior, and risk. *Mil Med* **2000**; 165:135–41.
72. Bruneau J, Daniel M, Kestens Y, Abrahamowicz M, Zang G. Availability of body art facilities and body art piercing do not predict hepatitis C acquisition among injection drug users in Montreal, Canada: results from a cohort study. *Int J Drug Policy* **2010**; 21:477–84.
73. He Y, Zhang J, Zhong L, et al. Prevalence of and risk factors for hepatitis C virus infection among blood donors in Chengdu, China. *J Med Virol* **2011**; 83:616–21.
74. Grasset D, Borderes C, Escudie L, et al. Le piercing des oreilles responsable d’une contamination par le virus de l’hépatite C [Hepatitis C virus from ear piercing]. *Gastroenterol Clin Biol* **2004**; 28:501–8.
75. Daniel AR, Sheha T. Transmission of hepatitis C through swapping body jewelry. *Pediatrics* **2005**; 116:1264–5.
76. Paintsil E, He H, Peters C, Lindenbach BD, Heimer R. Survival of hepatitis C virus in syringes: implication for transmission among injection drug users. *J Infect Dis* **2010**; 202:984–90.
77. Kamili S, Krawczynski K, McCaustland K, Li X, Alter MJ. Infectivity of hepatitis C virus in plasma after drying and storing at room temperature. *Infect Control Hosp Epidemiol* **2007**; 28:519–24.
78. Doerrbecker J, Friesland M, Ciesek S, et al. Inactivation and survival of hepatitis C virus on inanimate surfaces. *J Infect Dis* **2011**; 204:1830–8.
79. Steinman E, Ciesek S, Friesland M, Erichsen TJ, Pietschmann T. Prolonged survival of hepatitis C virus in the anesthetic propofol. *Clin Infect Dis* **2011**; 53:963–4.
80. Occupational Safety and Health Administration (OSHA). Occupational safety and health standard: bloodborne pathogens. Available at: [http://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=10051](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10051). Accessed 28 November 2011.
81. Armstrong ML. Tattooing, body piercing, and permanent cosmetics: a historical and current view of state regulations, with continuing concerns. *J Environ Health* **2005**; 67:38–43.
82. Strang J, Heuston J, Whiteley C, et al. Is prison tattooing a risk behaviour for HIV and other viruses? Results from a national survey of prisoners in England and Wales. *Criminal Behav Ment Health* **2000**; 10:60–6.